WATER HEATER SOLENOID PILOT OPERATED TEMPERATURE AND/OR PRESSURE CONTROL VALVE

Patent number: WO9966270
Publication date: 1999-12-23
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Classification:
- international: *F24H9/20; G05D23/13;* **F24H9/20; G05D23/01;** (IPC1-7): F24H9/20; F16K11/22; F16K31/128; F16K31/42; F24D19/10; G05D11/16; G05D16/20; G05D23/19
- european: F24H9/20A3; G05D23/13E
Application number: WO1999AU00472 19990615
Priority number(s): AU1998PP04106 19980615

Cited documents:
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- US395724
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Abstract of **WO9966270**

Hot water heater provides water at two preset temperatures (e.g. 50 DEG C and 80 DEG C) each at a different outlet. Controller (96) activates pilot solenoid (electromagnetic) valves (85, 89) of pressure actuated (diaphragm) flow control valve (102) to mix cold water with hot water from heat exchanger (51) at the higher temp. When flow is detected in the low temp. outlet by a sensor the same valve (102) provides water at the antiscald temp. Temperature sensor (95) provides feedback for accurate temperature control. Tempered water flow rate is controlled by another pressure actuated flow control valve (101) having pilot solenoid valves (93, 94), logic controller (96) and feedback from flowmeter (81); t e.g. compensate for a reduction in combustion gas pressure. Both solenoids (93, 94) may be opened when valve (101) controls temperature whereby bypass cold water mixes with hot water at venturi (76). Spring (70) and venturi (76) increase sensitivity. Computer controller also controls rate of gas flow dependent on water demand, fan formixing gas and air using e.g. oxygen sensor in flue and a display.

CORRECTED VERSION*

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F24H 9/20, F24D 19/10, F16K 31/42, 31/128, 11/22, G05D 16/20, 11/16, 23/19 — A1

(11) International Publication Number: WO 99/66270

(43) International Publication Date: 23 December 1999 (23.12.99)

(21) International Application Number: PCT/AU99/00472

(22) International Filing Date: 15 June 1999 (15.06.99)

(30) Priority Data:
PP 4106 15 June 1998 (15.06.98) AU

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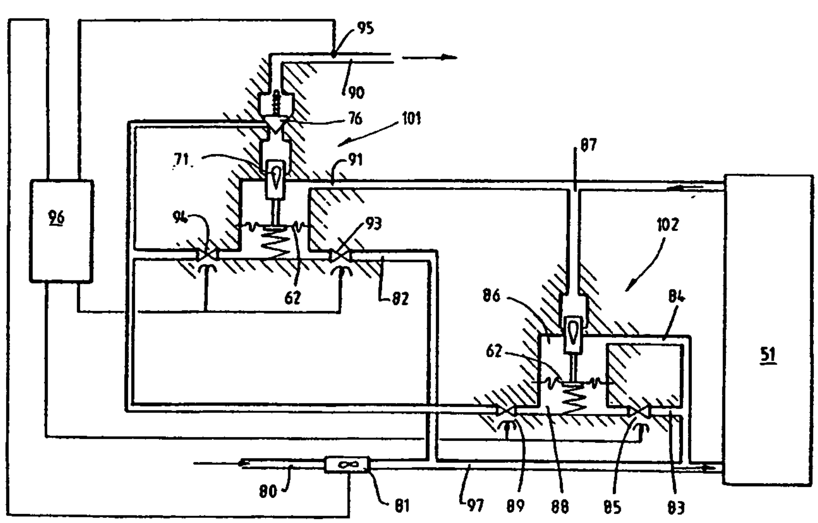
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: WATER HEATER SOLENOID PILOT OPERATED TEMPERATURE AND/OR PRESSURE CONTROL VALVE



(57) Abstract

Hot water heater provides water at two preset temperatures (e.g. 50 °C and 80 °C) each at a different outlet. Controller (96) activates pilot solenoid (electromagnetic) valves (85, 89) of pressure actuated (diaphragm) flow control valve (102) to mix cold water with hot water from heat exchanger (51) at the higher temp. When flow is detected in the low temp. outlet by a sensor the same valve (102) provides water at the antiscald temp. Temperature sensor (95) provides feedback for accurate temperature control. Tempered water flow rate is controlled by another pressure actuated flow control valve (101) having pilot solenoid valves (93, 94), logic controller (96) and feedback from flowmeter (81); to e.g. compensate for a reduction in combustion gas pressure. Both solenoids (93, 94) may be opened when valve (101) controls temperature whereby bypass cold water mixes with hot water at venturi (76). Spring (70) and venturi (76) increase sensitivity. Computer controller also controls rate of gas flow dependent on water demand, fan formixing gas and air using e.g. oxygen sensor in flue and a display.

*(Referred to in PCT Gazette No. 14/2000, Section II)

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WATER HEATER SOLENOID PILOT OPERATED TEMPERATURE AND/OR PRESSURE CONTROL VALVE

Field of the Invention

This invention relates to a flow control valve suitable for, but not restricted to, use in water heaters and in particular in instantaneous gas fired water heaters to provide hot water on demand.

Prior Art

Flow control valves are generally interposed along conduits in fluid flow systems and operate to control pressure, volume or direction of flow.

It is known to use flow control valves in water heaters and it is an object of the present invention to provide a flow control valve that will increase the reliability, efficiency and regulation of fluid flow in a fluid flow system such as in a water heater.

Summary of the Invention

According to the present invention there is provided a fluid flow control valve including a valve chamber, a control member dividing said valve chamber into first and second sub-chambers and movable in response to differences in fluid pressure between said sub-chambers, a valve member in said second sub-chamber and carried by said control member, a first inlet passage and a first outlet passage in communication with said first sub-chamber, a second inlet passage and a second outlet passage in communication with said second sub-chamber, a by-pass passage between said first and second outlet passages, a first valve in said first inlet passage and

a second valve in said first outlet passage or said by-pass passage, wherein said first and second valves are operable individually or in combination to vary the fluid pressure in said first sub-chamber relative to that in said second sub-chamber whereby said control member moves said valve member between a first position closing or partially closing the entrance to said second outlet passage to stop or decrease fluid flow through that passage and a second position away from the entrance to said second outlet passage to increase fluid flow through that passage.

Description of the Drawings

An embodiment of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a front elevational view of a water heater;

Figure 2 is a side elevational view of the heater;

Figure 3 is an opposite side elevation view of the heater;

Figure 4 is a schematic view of a first embodiment of a flow control valve that forms part of the water heater;

Figure 5 is a schematic view of a second embodiment of a flow control valve that forms part of the water heater; and

Figure 6 is a schematic view of a control system comprising two flow control valves of the water heater.

Description of Preferred Embodiments

The flow control valve shown in Figure 4 is designed for use in the domestic water heater illustrated in Figures 1 to 3. The water heater is fuelled by gas and operates

to provide an instantaneous flow of hot water thus there is no need for a tank to store a quantity of hot water.

As shown in Figures 1 to 3, the water heater 10 is housed in a rectangular enclosure 11 that is designed to be mounted flush against an external wall. The heater needs to be coupled to a supply of gas and it is understood that the heater can be adapted to work on a variety of commercially available gases. The exhaust gases are vented to the atmosphere via a small aperture 12 at the front 13 of the heater. Alternatively, the heater can be installed internally with exhaust gases being vented to the atmosphere via a small flue that would extend either through the wall cavity or up through the ceiling.

In summary, the water heater 10 comprises a series of gas burners 20 positioned above a water jacket assembly 50 so that heat from the gas burners 20 passes through a heat exchanger 51 that forms part of the water jacket assembly 50 to heat up a supply of cold water that is arranged to flow through the heat exchanger to exit the heat exchanger as hot water. A control mechanism controls the amount of gas that is burned at the burners 20 dependent on the flow of water ie on the demand. The burning capacity of the gas burners is enhanced by the provision of a fan 30 that mixes gas with air before the burners 20 to ensure use of the most efficient air fuel mixture. The fan 30 also operates to force the hot air generated by the burners 20 down in a vertical direction through the heat exchanger 51. Heat exchangers of this type produce condensation which drips down into a collection tray 71 mounted at the base of the enclosure

11 for discharge 72 into either the sewerage or storm water drains. It is understood that suitable plumbing would be used to facilitate this discharge.

The series of burners 20 are positioned across the top of the heater 10 and are fed by an air gas mixture via a mixing chamber 31 which is in turn fed from a modulating gas valve 32 and an electrically driven fan 30 that mixes the gas in the air prior to feeding the gas mixture to the burner. The burners 20 are in the form of a ceramic plate 35 having a series of small apertures (not shown) extending therethrough. The apertures provide a very large number of small flames that project downwardly towards the water jacket assembly 50. The flames are arranged to terminate at a position that is just above the position of the heat exchanger 51 that is positioned in the lower half of the water jacket assembly.

As shown in Figures 1 to 3, the cold water inlet 14 extends into the water jacket base on the left hand side of the unit as viewed in Figure 2 with the hot water exiting the water jacket assembly 50 from the right hand side of the unit towards the top of the heat exchanger 51 at the hot water outlet 15. Notwithstanding this arrangement it is understood that the direction of flow may be reversed. A water flow meter 90 monitors flow of water at the cold water inlet 14. A first temperature sensor T1 is positioned on the cold water inlet and a second temperature T2 sensor is positioned on the hot water outlet 15 from the heat exchanger 51. A third sensor T3 is positioned on a water flow control valve 60 which is coupled both to the cold water inlet 15 and the

hot water outlet 16. The supply of gas flows up from the base of the unit along one side through the modulating gas valve 32 to the fan 30 as shown in Figures 1 to 3. The hot water outlet 16 from the water valve 60 has a first outlet 17 that is designed to provide water at up to 80°C and a second lower temperature outlet 18 that dispenses water at up to 50°C via a flow sensor 19. The second lower temperature outlet 18 provides safety control to prevent scalding. The flow sensor that is coupled to the lower temperature outlet 18 ensures that a signal is sent to the controller when only the lower temperature outlet is in use to ensure that the water at that outlet is no more than 50°C. The combustion gases on passing through the heat exchanger 51 exit the unit at the base of the heat exchanger via the rectangular outlet 12 in the front face 13 of the heater. These gases are at a temperature that is lower than the temperature of the hot water for the main part of the water heater operation, thus the loss of the heat to the surrounding is kept to a minimum. Condensation can drip down into collection tray 71 for discharge via pipe 72.

An electronic controller 80 is mounted near the top of the heater as shown in Fig. 1 to control operation of the heater 10. To operate, the heater has to be coupled to a source of gas, a source of cold water and a source of electricity.

A gas pressure sensor 84 is positioned at the gas entry of the modulating gas valve 32 to sense a drop in gas pressure to reduce the output of the unit should there be a shortage of gas pressure. Conventional domestic

gas pressures operate to a maximum of 200 megajoules per hour in a domestic application and are limited by the gas pressure so that if too many appliances are used at once there is often a drop in the gas pressure. To ensure that a drop in gas pressure does not reduce the temperature of the hot water, the gas pressure sensor 84 causes the rate of flow of water to be reduced to compensate for a reduction in gas pressure so that the unit operates at the desired temperature albeit at a reduced output in terms of litres per minute. Another feature of the gas valve and controller is the use of an oxygen sensor that detects the amount of oxygen in the flue gases. If the flue gas mixture is either too lean or too rich, a signal is fed back to the controller 80 to change the gas flow to ensure an optimum mixture. The computerised controller 80 monitors three temperatures, namely the T1 which is the temperature at the inlet of the cold water, T2 the temperature at the heat exchanger outlet, and T3 which is the outlet hot water temperature of the unit. The third temperature monitor T3 is adjustable by which the user can adjust the desired output temperature. The controller 80 on sensing the three temperatures can then control the rate of water flow through the unit and also the gas input through the modulated gas valve 32 and the air input by varying the fan speed. The controller 80 varies the parameters to ensure maximum efficiency. The heater is designed to produce high volumes of water at primarily a 25°C temperature increase. A conventional shower uses 6 to 11 litres per minute which means that the heater can operate to run three to four showers at once without loss of temperature or reduced water flow.

The flow meter 90 positioned in the cold water inlet 14 comprises a substantially cylindrical casing that includes a deflector that deflects the flow of water and an impeller. The impeller is mounted on a shaft and is constructed of plastics material impregnated with magnetic material. To reduce corrosion of the impeller, an epoxy coating is positioned on the exterior of the impeller. The magnetic field that is caused by rotation of the impeller ensures that an electrical signal is produced that is responsive to the speed of rotation of the impeller. The speed of rotation is in turn dependent on the rate of flow of water pumped through the meter. The electrical signal that is produced by the flow meter 90 is then sent to the controller 80 to control the operation of the water heater in relation to demand. It is also understood that with this meter 90 a visual indication of the rate of flow through the meter can be displayed at the unit and/or at remote controls. The electrical signal that is produced by the flow meter 90 is then sent to the controller 80 to control operation of the water heater in relation to demand.

The flow control valve 60 is the subject of the present invention and as shown in Figure 4 comprises a valve chamber 61, sub chambers 61a and 61b separated by a piston member or, in this preferred embodiment, a flexible diaphragm 62 that is coupled on one side 61b to a flow constriction or valve member 63 that moves towards and away from a valve seat 64 at the outlet 65 of the valve. The sub chambers 61a and 61b are coupled to the inlet 14 and outlet 15 of the heat exchanger 51. The sub chamber 61a is also coupled to the cold water inlet 14 via a first solenoid cut-off valve 67. The sub

chamber 61a is also coupled to the outlet 65 through a by-pass conduit 69 cut-off via a second solenoid valve 68. There is a pressure drop across the heat exchanger which means that P1 at the inlet is greater than P2 at the outlet which is in turn greater than the exit pressure P3.

In operation of the flow control valve the solenoid valves are generally closed, however, if there is too much demand for hot water and a need to reduce the flow, the first solenoid cut-off valve 67 opens while the second solenoid valve 68 remains closed which has the effect of causing a greater pressure P1 in the sub chamber 61a which forces the diaphragm and the valve 63 to partially close against the seat 64 to reduce output flow. If an increase in flow is required, the first solenoid valve 67 closes and the second solenoid valve 68 opens which has the effect of reducing the pressure difference across the diaphragm which causes the diaphragm to resiliently return to open the valve 63 to increase the output flow. In a situation where the heat exchanger 51 has an excess quantity of hot water and there is a danger that the hot water will overshoot the maximum temperature, both solenoid valves 67 and 68 open which has the effect of causing a proportion of cold water to flow from the inlet 14 past the diaphragm into the outlet via the second solenoid valve 68 and conduit 69. This in turn cools down the temperature of the outlet water to ensure that it is within the desired parameters.

A further embodiment of the flow control valve is illustrated in figure 5 and includes additional features

to the embodiment shown in figure 4 which increase sensitivity of the response of the moving diaphragm by increasing the pressure differential between the sub chambers. Consequently, control of fluid through the flow control valve is enhanced, this being particularly advantageous with low fluid pressure situations. A spring 70 located in the first sub chamber and biased against the diaphragm increases sensitivity of the moving diaphragm. In this embodiment the valve member, which constricts the flow through the second outlet, is a piston 71 having a key hole shaped aperture 72 extending radially through the piston. Specifically, one end of the key hole shaped aperture is wider than the other end such that more fluid flows through the wider end than the narrower end. Depending therefore on the position of the valve in the valve seat 64, the flow of water through the second sub chamber can be varied.

Valve seat 64 is located at an outlet chamber 74. A second valve seat 75 at the opposite end of the outlet chamber 74 to valve seat 64, supports a second valve member 76 which is normally biased towards second valve seat 75 reducing the cross sectional area of seat 75. A spring 77 forces valve member towards seat 75. In this embodiment the valve 76 and seat 75 act as a nozzle accelerating flow past the second valve member 76 to the outlet 65. The accelerated flow causes the by-pass conduit 69 to act as a venturi thus reducing the effective pressure in sub chamber 61a and counteracting the effect of the spring 70.

The embodiment of the flow control valve depicted in figure 5 operates similarly to the embodiment depicted

in figure 4 in that the first solenoid cut-off valve 67 opens to create a greater pressure in the sub chamber 61a if there is need to reduce the flow through the control valve. An increase in pressure in sub chamber 61a urges the spring biased diaphragm 62, which is normally positioned open of seat valve 64, to move the valve member to reduce the flow or completely close seat valve 64. Movement of the diaphragm towards seat 64 is assisted by spring 70. When it is desired to increase the flow through the flow control valve, the second solenoid valve 68 opens and the first solenoid valve 67 closes so that fluid contained in sub chamber 61a flows through by-pass conduit 69 to exit at the second outlet 65. However, second valve member 76 is spring biased against second valve seat 75 so that the force from the fluid flowing from the second inlet through the second sub chamber lifts the second valve member 76 slightly off seat 75. This results in a high velocity flow of fluid past valve member 76 thus causing the venturi in by-pass conduit 69 and the drop in pressure experienced in sub chamber 61a. Thus the increased pressure differential across the diaphragm causes the diaphragm to resiliently return to open piston 71 and increase output flow.

As with the embodiment depicted in figure 4, the embodiment of the flow control valve depicted in figure 5 is also a mixer valve. The control valve is capable of allowing a proportion of cold water to mix with hot water at the outlet to reduce the output water temperature. Both solenoid valves 67 and 68 open to allow a proportion of cold water intended for the heat exchanger to flow through sub chamber 61a, through by-

pass conduit 69 to exit at the second outlet 65. Meanwhile, hot water from the heat exchanger 51 enters second sub chamber 61b and flows through the aperture 72 in the piston 71 to enter outlet chamber 74, mixing with cold water from the by-pass conduit to flow through the outlet 65.

The flow control valve thus acts as a mixing valve as well as a flow controlling valve. The features of the control valve described with reference to figure 5 enhance the sensitivity of diaphragm movement.

Figure 6 illustrates a control system 100 combining a flow control valve 101 and a temperature control valve 102. Cold water flows into the system at system inlet 80 and flows past flow meter 81. The water flow then divides and flows into two conduits: one conduit leading to a first inlet of the flow control valve 82; the second conduit 97 leading to the temperature control valve. Water flowing to the temperature control valve separates in three directions: to the first inlet of the temperature control valve 83; to the second inlet of the temperature control valve 84 and through the heat exchanger 51. When first temperature solenoid 85 is closed a proportion of cold water flows through second sub chamber 86 of temperature control to outlet 87 to mix with hot water from heat exchanger 51. The hot water then flows to the flow control valve for flow regulation and finally through system outlet 90. If it is desired to increase the temperature output through the system 100 first temperature solenoid valve 85 is opened to allow water to flow through first inlet 83 into first temperature sub chamber 88. The second

temperature solenoid 89 is closed. Thus, the diaphragm in the temperature control valve moves under the pressure difference between the sub chambers causing the temperature control piston to prevent cold water from second inlet 84 to pass through to temperature outlet 87. Opening second temperature solenoid 89 will once more allow cold water to flow through the temperature control valve to mix with hot water.

Hot water from heat exchanger 51 and temperature control valve 102 enters the second inlet 91 of the flow control valve. It then passes into second sub chamber through the flow control piston 71 and past valve member 76 and exits through system outlet 90. To reduce the flow of hot water the first solenoid valve 93 of the flow control valve opens to allow water from first inlet 82 to flow into the first flow control sub chamber. The flow control diaphragm 62 moves under the pressure differential between the sub chambers to reduce or close the passage of flow through the flow control valve. Closing the first flow control solenoid 93 and opening the second flow control solenoid 94 causes the diaphragm to resiliently move back to its original position thereby increasing the flow of hot water through the flow control valve.

A temperature sensor 95 at the system outlet 90 and flow meter 81 monitor the output temperature and input flow rate. Temperature sensor 95 and flow meter 81 signal to controller 96 which accordingly responds varying the temperature or flow control of the system.

To start up the heater, an electrically operated glowing

surface or spark ignition is utilised in the combustion chamber and the control ensures that when the tap is turned on causing flow of water, there is first a pause to purge any combustible gases within the combustion chamber. Then, there is a short pause during which the glow surface ignitor commences to glow or spark ignition activates and then an air gas mixture enters the combustion chamber. If there is no combustion, the water heater shuts down the gas flow and the whole process is repeated. If this fails on two occasions then the unit shuts down and a warning light comes on warning the user of the system that a service call is required.

Since modification within the spirit and scope of the invention may readily be effected by persons skilled within the art, it is to be understood that this invention is not limited to the particular embodiment described by way of example hereinabove.

CLAIMS:

1. A fluid flow control valve including a valve chamber, a control member dividing said valve chamber into first and second sub-chambers and movable in response to differences in fluid pressure between said sub-chambers, a valve member in said second sub-chamber and carried by said control member, a first inlet passage and a first outlet passage in communication with said first sub-chamber, a second inlet passage and a second outlet passage in communication with said second sub-chamber, a by-pass passage between said first and second outlet passages, a first valve in said first inlet passage and a second valve in said first outlet passage or said by-pass passage, wherein said first and second valves are operable individually or in combination to vary the fluid pressure in said first sub-chamber relative to that in said second sub-chamber whereby said control member moves said valve member between a first position closing or partially closing the entrance to said second outlet passage to stop or decrease fluid flow through that passage and a second position away from the entrance to said second outlet passage to increase fluid flow through that passage.

2. A fluid flow control valve as claimed in claim 1 wherein the fluid flow control valve is used to control flow rate and/or temperature of fluid through the second outlet passage.

3. A fluid flow control valve as claimed in any one of the preceding claims wherein the control member is biased against a spring located in the first sub-

chamber.

4. A fluid flow control valve as claimed in any one the preceding claims wherein the valve member is a piston having a key-hole shaped aperture therethrough.

5. A fluid flow control valve as claimed in claim 3 wherein a second valve member is provided at a junction between the by-pass passage and the second outlet to increase the velocity of flow through the second sub chamber thereby creating an increased pressure difference across the diaphragm.

6. A fluid flow control valve as claimed in any one of the preceding claims wherein a heat exchanger is provided between the first inlet passage and the second inlet passage.

7. A fluid flow control valve as claimed in any one of the preceding claims wherein the first and second valves are electronically controlled solenoid operated valves responsive to a flow meter and/or temperature sensor.

8. An instantaneous gas fired water heater including:

a cold water inlet;

a heat exchanger;

a gas burner;

a hot water outlet; and

a fluid control valve having a fluid flow control valve including a valve chamber, a control member dividing said valve chamber into first and second sub-chambers and movable in response to differences in fluid pressure between said sub-chambers, a valve member in said second sub-chamber and carried by said control member, a first inlet passage and a first outlet passage in communication with said first sub-chamber, a second inlet passage and a second outlet passage in communication with said second sub-chamber, a by-pass passage between said first and second outlet passages, a first valve in said first inlet passage and a second valve in said first outlet passage or said by-pass passage, wherein said first and second valves are operable individually or in combination to vary the fluid pressure in said first sub-chamber relative to that in said second sub-chamber whereby said control member moves said valve member between a first position closing or partially closing the entrance to said second outlet passage to stop or decrease fluid flow through that passage and a second position away from the entrance to said second outlet passage to increase fluid flow through that passage.for controlling flow rate and/or temperature of fluid through the second outlet passage.

9. A fluid flow control valve substantially as herein described with reference to and as illustrated by the accompanying drawings.

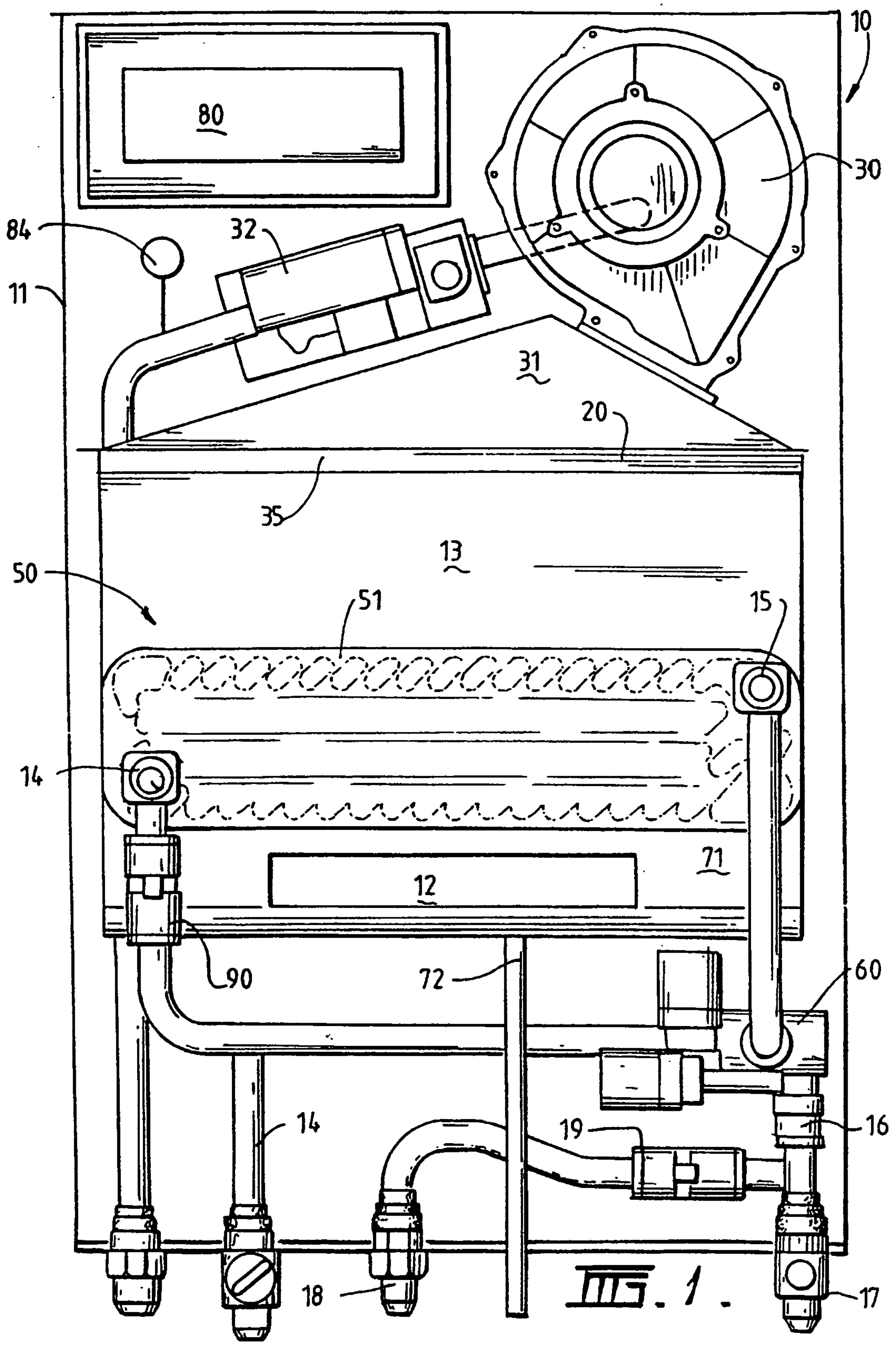
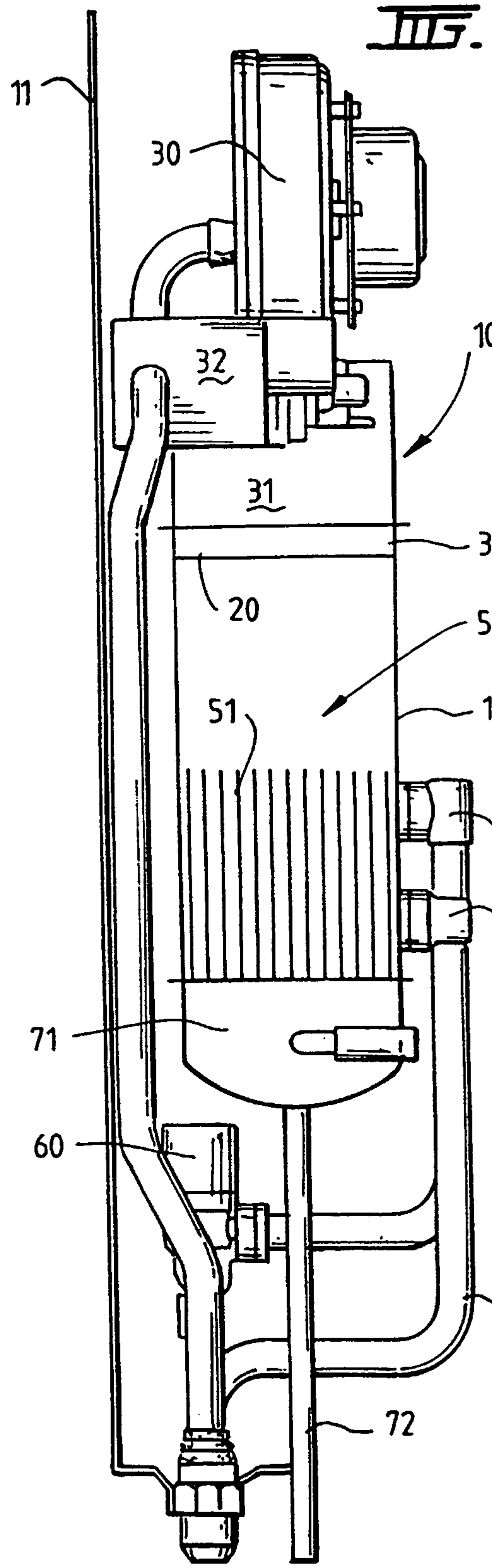


FIG. 1.

FIG. 2.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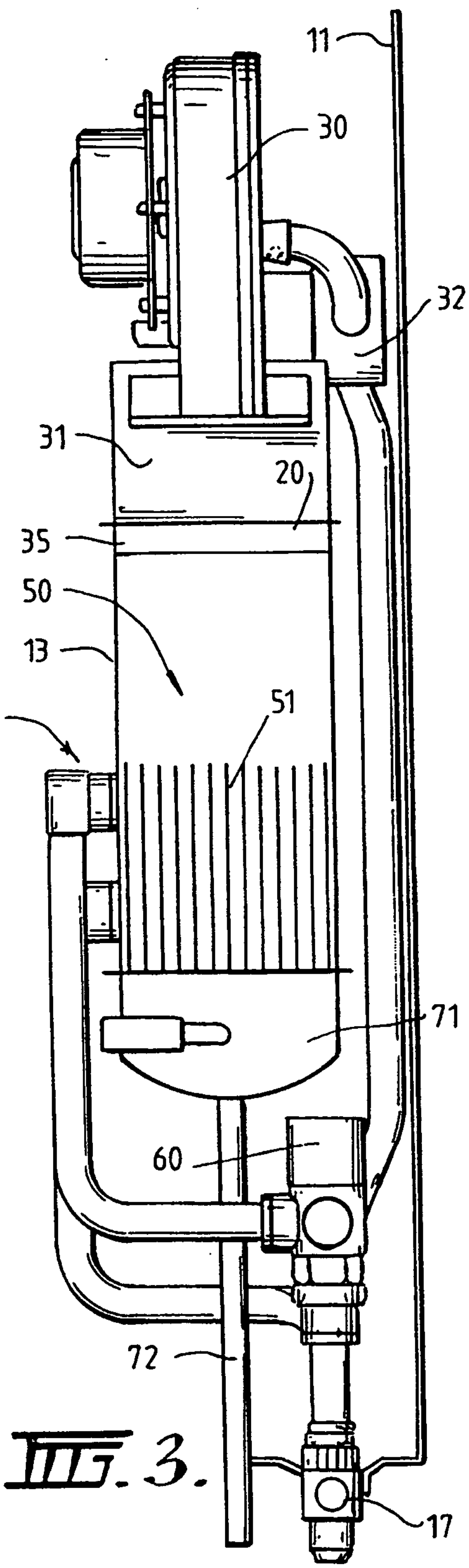
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FIG. 3.

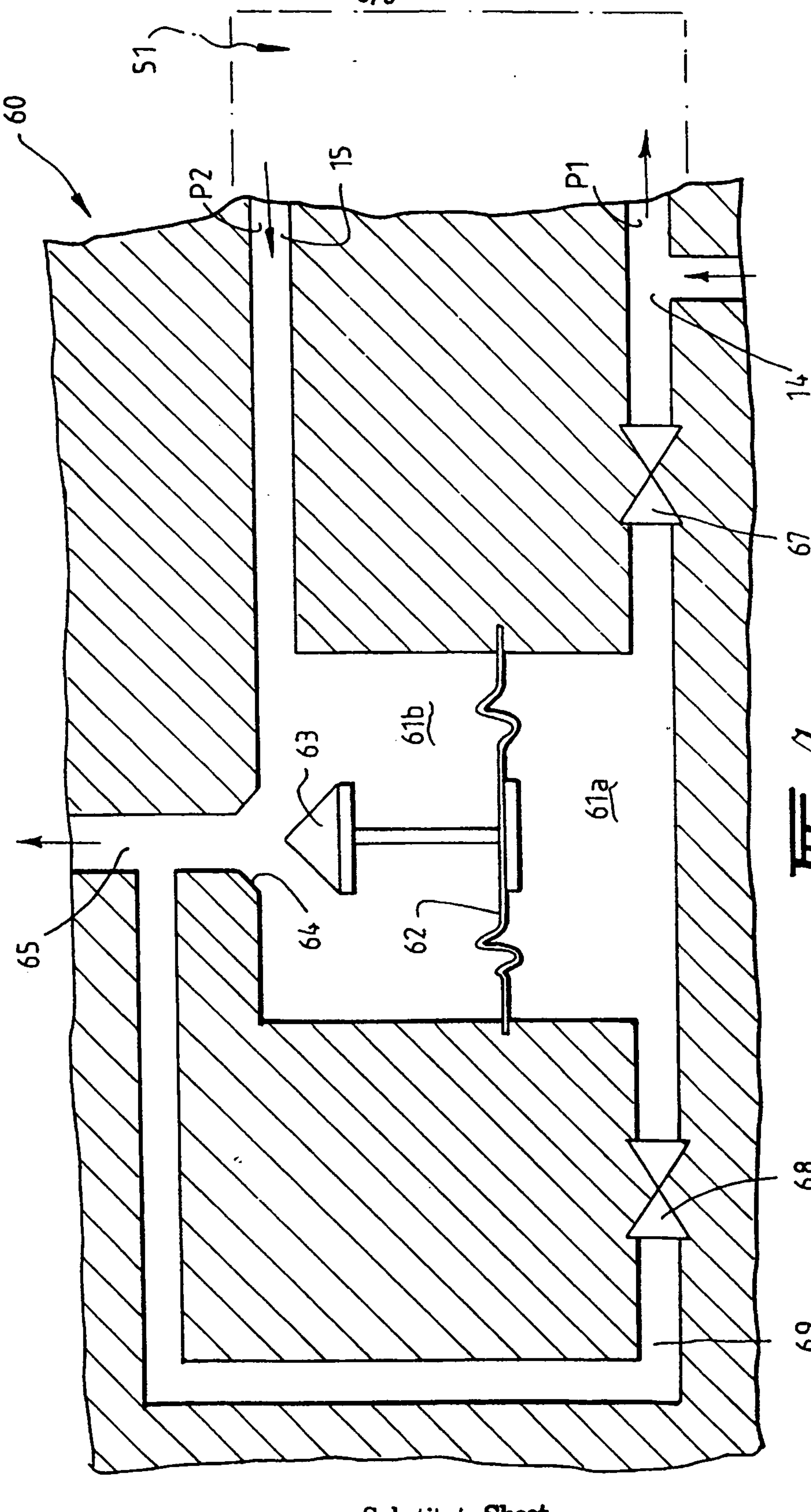
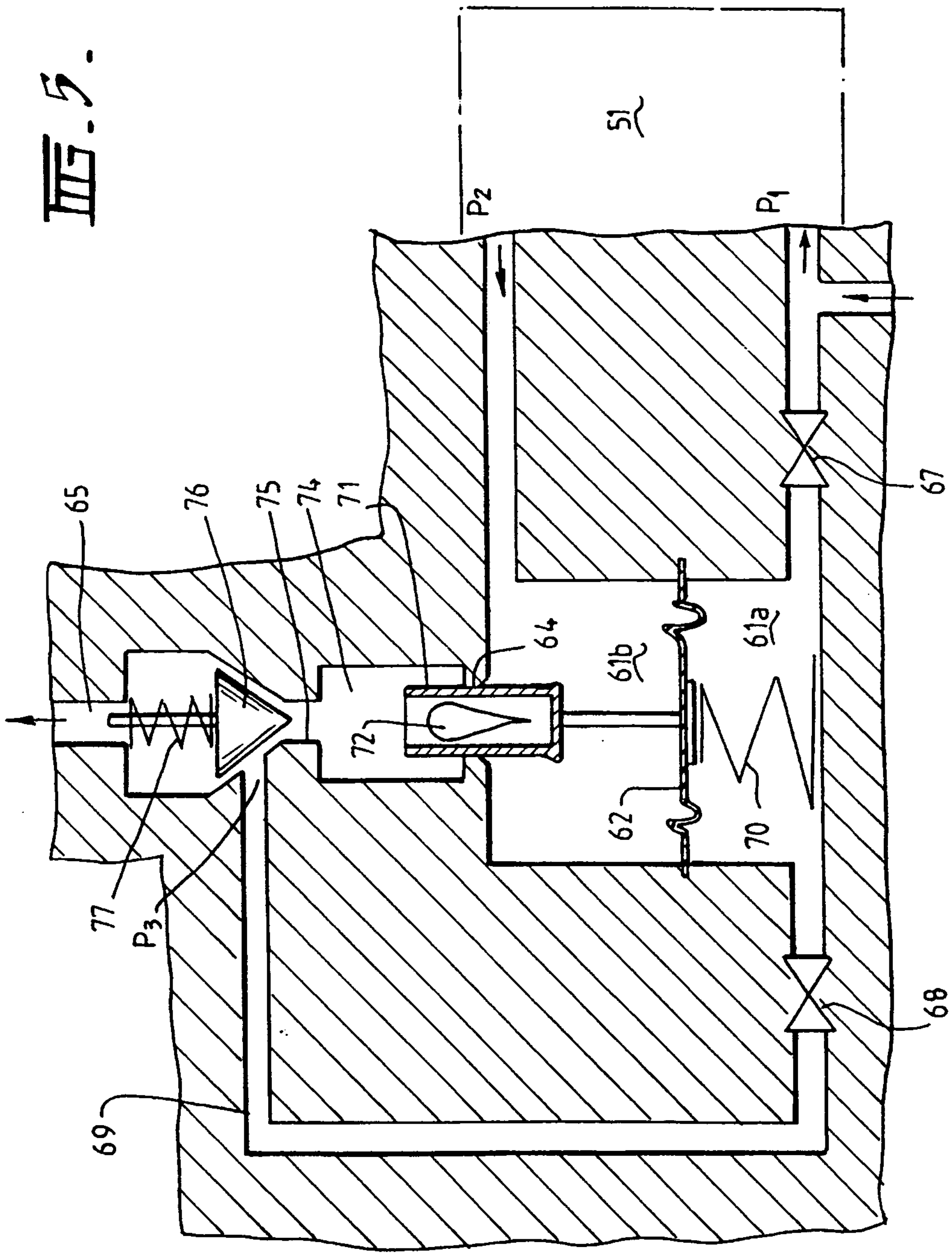


FIG. 4.

FIG. 5.



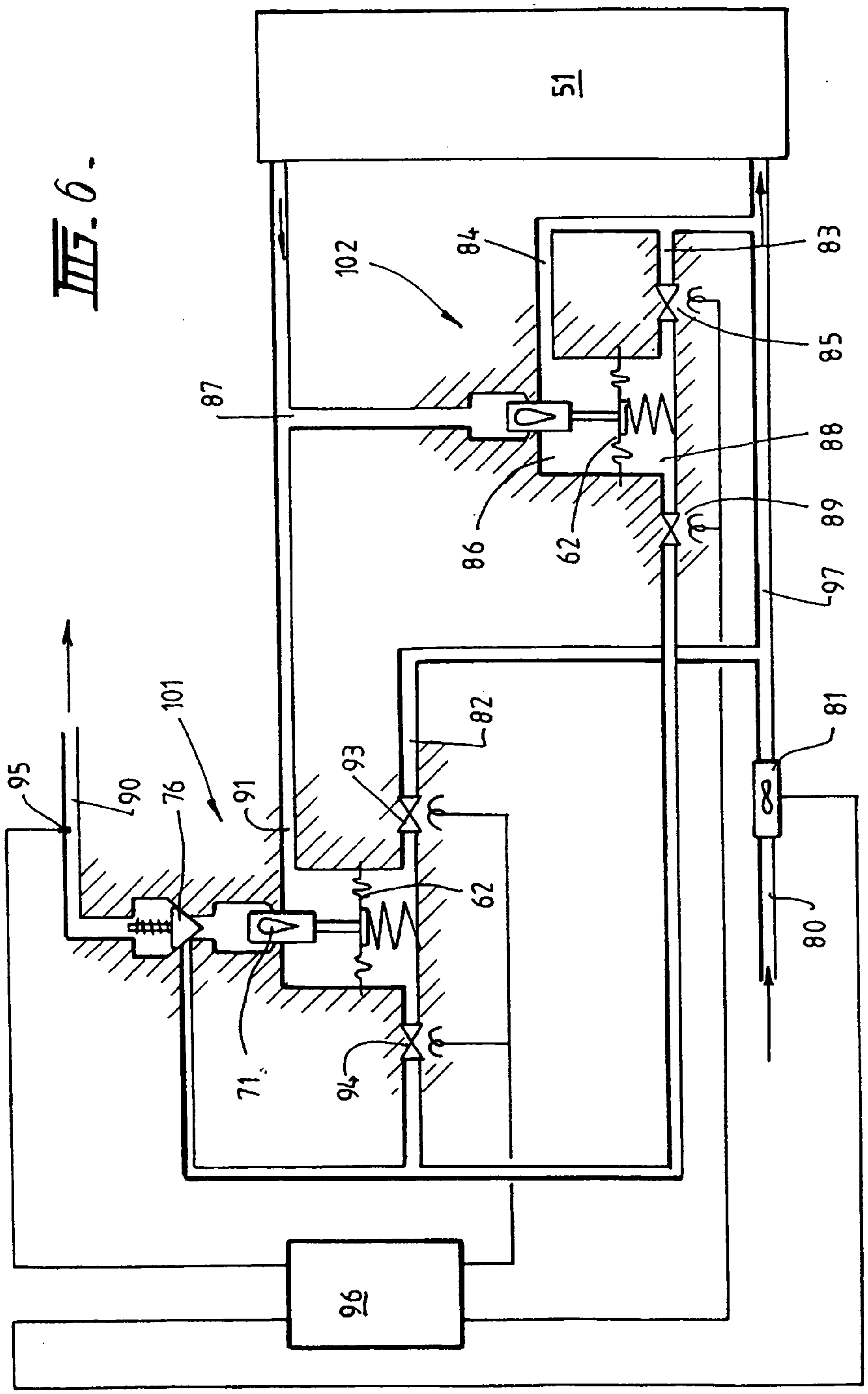

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FIG. 6.

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU 99/00472

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl^{6}: F24H 9/20, F24D 19/10, F16K 31/42, 31/128, 11/22, G05D 16/20, 11/16, 23/19

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: IPC as above AND KEYWORDS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 042 775 A (WILLEMSEN) 27 August 1991 Whole document	1-4, 7
X	US 3 957 244 A (CHAUVIGNE) 18 May 1976 Whole document	1-4, 7
X	US 3 904 167 A (TOUCH et al.) 9 September 1975 Whole document	1-4, 7

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

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Date of the actual completion of the international search	Date of mailing of the international search report
16 August 1999	09 SEP 1999

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 295 034 A (ROBERT BOSCH GmbH) 15 May 1996 Whole document	1-4, 7, 8
P,X	EP 855 561 A (ROBERT BOSCH GmbH) 29 July 1998 Whole document	1-3, 7, 8
A	GB 2 304 875 A (TRITON PLC) 26 March 1997 Figure 1	6, 8

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU 99/00472

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5042775	AT	77683	DE	3872385	EP	343288
		ES	2032950				
US	3957244	CH	580246	DE	2450094	FR	2250059
		GB	1439913	IL	46047	IT	1025282
		JP	50112821	SE	408949		
GB	2295034	CN	1128855	DE	4440492		
EP	855561	DE	19702686				

END OF ANNEX